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LEED Construction and Performance Standards Mission Accomplishment

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The general focus of the project is on the current state of Leadership in Energy and Environmental Design (LEED) building requirements and mission statement accomplishment. The report includes the background, requirements, and performance of LEED certified buildings, and identifies key issues with the current system. In particular, the report explores the failure of buildings construct to LEED standards to achieve the advertised energy savings. Solutions and avenues to implementation of the solutions are then offered.

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Capstone

COVER LETTER

This is the final report for the ENMA 605 Capstone Course project; the purpose of which is to demonstrate a application of the appropriate concepts, techniques, and knowledge gained during the course of study for the Master of Engineering Management degree. The topic of the research project is the Leadership in Energy and Environmental Design (LEED) program, the premier "green" building system. This report details the difference between the normative and current LEED systems. It offers recommendations on how to change the current system to address the problems associated with the program. The LEED program was chosen because it is a mandated requirement for the construction of new Federally funded buildings. Following graduation from this degree program, I will oversee construction for the Naval Facilities Engineering Command (NAVFAC) in Hawaii. A better understanding of the goals and shortcomings of the LEED program will allow me to be more successful in executing my duties.

As a capstone of the degree program, this report is not purely a reflection of the status of the LEED program, problems, and solutions. It also includes a description of the process of the system analysis. This process details the project design, approach, scope, objectives, purpose, and management. Therefore, the project report is not presented in the same format as a normal report, but was broken into sections explaining how the project was undertaken, as well as the findings of the project. Unlike a thesis, the capstone project was limited in time. Consequently, the scope of the project was restricted to the time and resources afforded by the length of one semester. For example, in an attempt to collect primary data required for a deep analysis of the LEED problem system, it became apparent this effort level was out of the scope of the project. All of the information for this report is secondary data and the conclusions of the report are only

as good as the data collected. This shortcoming has been addressed by collecting data from as many sources as possible to uncover conflicting information. The report succeeded in developing a problem system, determining potential solutions, and identifying areas of further research. This meets the requirement of demonstrating the ability to apply the knowledge gained in the ENMA program to analyze a problem system.

LEED Construction and Performance Standards Mission Accomplishment

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EXECUTIVE SUMMARY

Background:

Due to the design and construction requirements of the Energy Policy Act (EPAct) of 2005 and the Executive Order 13423 (Presidential Documents, 2007), all new buildings and major renovations, where the work exceeds 50% of the building's plant replacement value (PRV), must comply with EPAct 2005 (NAVFAC, 2007). This EPAct states all projects must be registered as certified by the U.S. Green Building Council (USGBC) as meeting the Leadership in Energy and Environmental Design (LEED) Silver rating. To earn a LEED Silver rating, a building project must earn a minimum number of points by following the LEED point system and by meeting all minimum design characteristics as required by LEED program. Prior to being awarded any points, the construction site and building must be inspected by a LEED certified inspector at key points during construction and at commissioning (USGBC, 2012). For the current fiscal year of 2013 (October 2013 to September 2014), the military new construction budget is $9.6 billion (U.S. Department of Defense, 2012). Studies have found that building to the LEED Silver level to add a 2% premium to new construction (Kats, Alevantis, Berman, Mills, & Perlman, 2003) (Nyikos, Alfred Thal, Hicks, & Leach, 2012) (Stegall, 2004). Thus, the mandate adds $192 million to the annual construction costs. Despite the money being spent on the program, there has yet to be a comprehensive third party review of the holistic success of the program's stated goals.

Purpose and Objectives:

The purpose of the course project is to investigate if the current LEED program is meeting the stated system goals, and how those goals could be better met by:

1. Identifying failures to meet system goals.
2. Identifying the causes of these failures.
3. Identifying possible solutions and avenues to implement the solutions.
4. Identifying areas for further research.

General Approach:

The approach used in this project is a literature review of relevant materials to find the state of the LEED system and to collect data on system operation. This data was then analyzed to determine system problems, problem causes, and solutions.

Findings/Results:

The LEED program currently meets all stated goals except for energy saving. This is due to emergent disincentives for energy savings and lack of accountability for failing to achieve claimed energy saving in actual building operation.

Conclusions and Recommendations:

Though the primary stakeholders in the current system seem to be satisfied, the system is failing to produce the advertised product. The solution to this is proactive systemic changes by USGBC to greater incentivize energy savings and to hold the owners of the building responsible for the commissioning simulations used to certify the building. If USGBC falls to unilaterally take action to address the problem system, legal action by an organization with standing could affect change externally. Future research should be done by tracking actual energy usage in LEED certified buildings. This data could be used to ensure the LEED program is meeting expectations.

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INTRODUCTION

GENERAL FOCUS OF THE PROJECT

The general focus of the project is on the current state of Leadership in Energy and Environmental Design (LEED) building requirements and mission statement accomplishment. The report includes the background, requirements, and performance of LEED certified buildings, and identifies key issues with the current system. In particular, the report explores the failure of buildings construct to LEED standards to achieve the advertised energy savings. Solutions and avenues to implementation of the solutions are then offered.

ORGANIZATION FOR THE PROJECT

USGBC is a group which included architects, realtors, building owners, lawyers, environmentalist, and construction industry representatives. USGBC's mission statement is: "To transform the way buildings and communities are designed, built and operated, enabling an environmentally and socially responsible, healthy, and prosperous environment that improves the quality of life for all (USGBC, 2013)." Their goal was to set a national standard for "green" building construction, which resulted in the LEED program. They then lobbied the federal government to implement the standards, which was done by President Bush in 2007 with Executive Order 13423 and codified into law by the 2009 Omnibus Appropriations Act as discussed above.

The LEED program mission statement and brief overview is as follows:

> The LEED 2009 Green Building Rating System for New Construction and Major Renovations is a set of performance standards for certifying the design and construction of commercial or institutional buildings and high-rise residential buildings of all sizes, both public and private. The intent is to promote healthful,

> durable, affordable, and environmentally sound practices in building design and construction. Prerequisites and credits in the LEED 2009 for New Construction and Major Renovations addresses seven topics: Sustainable Sites, Water Efficiency, Energy and Atmosphere, Materials and Resources, Indoor Environmental Quality, Innovation in Design, and Regional Priority. Certifications are awarded according to the following scale: Certified 40–49 points, Silver 50–59 points, Gold 60–79 points, Platinum 80 points and above (USGBC, 2012).

Each of the above seven topics were then broken into subparts which were assigned a point value. For example, if at least one principal participant of the project team is a LEED accredited professional, the project is given one point. Bike racks and light pollution reduction are additional examples of avenues to gain a single point. Other actions, such as water and energy usage reduction are worth more points. One of the strengths and weakness in the LEED system was the standardization of requirements to build a "green" building. This is a weakness because it does not allow much flexibility in designing for regional issues. However, it does ease the design process for construction/design companies which operate on a national or international level. Prior to the LEED system implementation, different regions and institutions had developed local requirements for "green" buildings (Stegall, 2004) (Oates & Sullivan, 2012). The LEED program sets a baseline expectation between the solicitor and bidders on the contractual obligations relevant to constructing a "green" building. Overall, the movement towards building "green" buildings has been bipartisan, and has been supported by both President Bush and President Obama.

IMPORTANCE OF THE ISSUE/PROBLEM RESOLUTION

The goals set by the LEED program addresses some of the issues facing the country. The program aims to reduce urban sprawl, make the operation and travel to and from LEED buildings less sensitive to volatile energy costs, promote development of new technologies and energy sources, reduce pollution, support the health and productivity of building occupants, and support the use of recycled/renewable construction materials. Not only are these causes important on their own merits, but this program also creates the markets in support of "green" construction which were limited or nonexistent prior to this program. These markets decreases the overall cost of meeting the above goals, and increases the chances of implementation in non-LEED buildings.

PROJECT DEFINITION

DEFINITION OF THE PROJECT FOCUS

PURPOSE:

I chose this project because I am a Naval Civil Engineer Corps officer in the U.S. Navy. After graduation from the Engineering Management program at Old Dominion University, I will be stationed in Hawaii, where I will oversee new construction management for the area. As LEED Silver certification is required for all buildings under my purview, an intimate knowledge of the LEED program will help ensure the program goals are met. By identifying key shortcomings in the current program, I will be better positioned to focus on those areas.

OBJECTIVES:

1. Identify the LEED program goals.
2. Identifying failures to meet system goals.
3. Identifying the causes of these failures.

4. Identifying possible solutions.
5. Identify avenues to implement the solutions.
6. Identify areas for further research.

PROJECT SCOPE:

In discussing the virtues of LEED construction, the following should be kept in mind:

> Virtually no data has been collected on conventional buildings to determine what the building would cost as a green building. And, surprisingly, most green buildings do not have data on what the building would have cost as a conventional building. To be useful for this analysis, cost data must include both green building and conventional design costs for the same building. Typically this data is based on modeling and detailed cost estimates. LEED does not currently require that cost data for both conventional and green design be submitted. (Kats, Alevantis, Berman, Mills, & Perlman, 2003)

As part of this investigation, the originally desired approach to be used was a literature review of relevant materials, data collection and interpretation from the operation of LEED Silver buildings, and interviews with construction and building managers. While any data gathered for this project would be secondary data, the degree of separation from primary data would have been reduced by collecting data directly from building managers. Initially, this seemed achievable. Numerous LEED certified buildings exist in the Hampton Roads area. Through my position as an U.S. Navy Civil Engineer Corps officer, I should have had access to this information from the naval installations in the area. In addition, I had a contact with the Department of Defense Education Activity (DoDEA), whom oversees school construction for the

Army Corps of Engineer and had agreed to support this project. However, collecting data on energy usage for these buildings proved unsuccessful.

Discussions with the City of Norfolk indicated that data is either not tracked or not available for research of this scope. According to the Army Corps of Engineers, which oversaw the construction of the City of Norfolk buildings, the Corps is not involved in the operations of buildings post commissioning and does not track energy usage. The Navy does keep records of energy usage, however, the simulations used in the commissioning of the buildings were not available. In addition, the Navy buildings energy records are of limited use. All buildings built by the Navy after Executive Order 13423 took effect are minimally LEED Silver certified. The only conventional buildings available for comparison operated by the Navy, are significantly older and do not have the advantage of modern materials, lighting and environmental control systems, and modern building techniques. To give an accurate representation of the success of the LEED buildings, they need to be compared to buildings built in the same time frame, in the same general region, and for similar use. Thus for this data to be useful, data would have to be collected from either public or private buildings in Hampton Roads. Sadly, the energy usage for these buildings is not tracked. To gather primary data, a program to track the energy usage would have to be implemented, which is out of the scope of this project. This lack of energy usage data is in keeping with information found in the literature review. Over half of LEED certified buildings did not track energy usage or refused to divulge the information (Gifford, 2009) (Kats, Alevantis, Berman, Mills, & Perlman, 2003) (Nyikos, Alfred Thal, Hicks, & Leach, 2012) (Oates & Sullivan, 2012) (Scofield, 2009). Thus the data for this project is from a review of existing literature.

PROJECT SIGNIFICANCE

LOCAL LEVEL IMPACT:

If the recommendation of this project were to be taken under advisement, the local building managers for LEED buildings should begin tracking energy usage and compare this data to the simulation used in the building commissioning. Though it was outside of the scope of this project to obtain the simulations, they should be attainable by the building owners through the USGBC archives. If the building is found to not meet expectations, the building manager should first determine if the building is being operated in a manner which is responsible for the lack of energy savings. If the operations are not the problem, the construction company and USGBC may be liable for selling a product which does not perform as advertised.

APPLICATION OF ENGINEERING MANAGEMENT KNOWLEDGE:

To successfully complete this project, a knowledge of complex systems analysis was required to both holistically and reductively analyze the system. From the holistic standpoint, how the system supports "green" construction was needed. Using a reductive approach assisted in understanding how each component of the program supported the overarching goals of the system. An understanding of statistics and financial projection estimation were required to dissect the relevant literature. In addition, the ability to perform project management kept the project on track during a compressed time period.

POTENTIAL EXTENSION OF PROJECT APPROACH OR FINDINGS BEYOND THE LOCAL APPLICATION:

The USGBC has certified LEED buildings in 150 countries and territories worldwide, this includes over 10.5 billion square feet of building space, and over 10,000 projects. (Katz, 2012). The lack of energy savings potentially effects up to 94% of these buildings (Oates &

Sullivan, 2012). The main obstacles to action being taken on this issue seem to be apathy on the part of the building operators and general satisfaction of the stakeholders in the current state of the system products. Also, to prove damages may be difficult as there are many variables in the commissioning simulation which may confound the results. For example, if the number of people in the building are greater than was anticipated in the simulation, then the extra energy use could be attributed to the increase in occupants. Thus, it could be argued the simulation was correct and the building was not being used as designed. Without perfecting matching the conditions of the simulation, actual energy usage discrepancies would be difficult to prove. In addition, one study found the extra annual costs for not meeting the energy goals are $8,410 to $13,744 on average (Oates & Sullivan, 2012). Even if the building operators of a single building were refunded the difference, the ROI for suing probably is not positive. The largest stakeholder in this program is the U.S. Federal Government. However, the effort required to record the energy usage data across departments and compare this to the commissioning studies is daunting. Thus, though potentially over $100 million is being spent annual because of the non-existent energy savings, the system is unlikely to change.

PROJECT APPROACH

PROJECT DESIGN OVERVIEW

The process used in this project was a System of Systems Engineering (SoSE) methodology to conduct a literature review of publications in relation to the LEED program and then to analyze the resulting data to find problems in the systems, causes of the problems, and develop potential system solutions.

SPECIFIC PROJECT DESIGN

DATA COLLECTION:

The source of data collection for this project was a review of relevant literature. As discussed above, primary data was either not available or not necessarily helpful because there was no relevant data available for comparison. To use the primary data, the simulations used during building commissioning would have been required. Also, data from non-LEED building in the same region, vintage, and usage would be necessary. These buildings exist, but energy usage is not tracked.

PLAN FOR DATA ANALYSIS:

SoSE is not prescriptive and any portion of the methodology can be applied or revisited at any time. However, SoSE is broken roughly into four steps: defining the problem system of interest, problem system analysis, target system synthesis, and transformation strategy. Defining the problem system of interest is further broken down into: normative system, current system, and context. The normative system is a model or sketch of how the system would be if it was producing the desired outcomes. The current system is a combined picture of the system as it presently exists from the viewpoints of multiple observers. The context of the system are those factors which enable and constrain the system boundaries and functions. The analysis was conducted by exploring the differences between the normative system and the current system, determining the causes of this difference, and targeting the mechanisms which could be changed to eliminate the differences. Target system synthesis is the formulation of system changes achievable within the constraints found in the context of the system. This was done by describing the system changes possible to make the system purpose match the system goals. The transformation strategy was completed by fielding a series of possible solutions, how they could be accomplished, and the likelihood of them being accomplished.

RESULTS OF DATA COLLECTION:

The systems analysis effort will be considered a success if the problem system is clearly defined, the mechanisms driving the problem system are identified, and actionable recommendations are presented. As this research project is unsolicited by the stockholders, implementation of these recommendations will not be required for a successful systems analysis effort.

PROJECT MANAGEMENT

A. Milestones:

March 01 – Initial problem framing and initial literature review completed

March 02 – Proposal Submitted

March 04 – Meet with the NAVFAC/Army Corps representatives

March 15 – Analytic Strategy Completed

March 25 – Data collection completed

April 01 – Analysis completed and recommendations formulated

April 21 – Project rough draft completed

May 05 – Final Project Submitted

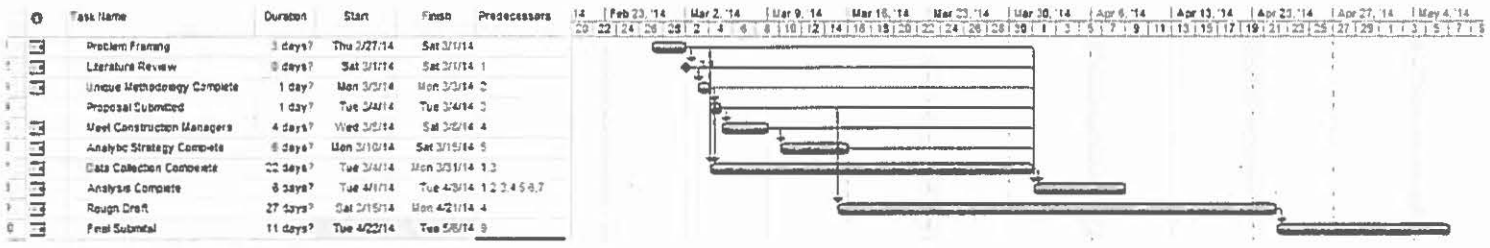


Figure 1: Work Breakdown Structure

B. Sequence of activities:

C. As this project was an individual effort, the only aspect which needed managed was my

personal time allocation. However, the data collection was not complete by 25 March, requiring me to "crash the schedule" and conduct the data analysis in parallel to data collection in order to be complete by mid-April.

PROJECT DESIGN ISSUES

As discussed above, the primary project design issue centered on the lack of primary data. Though it seems intuitive after the fact, the lack of data for non-LEED buildings for comparison purposes was unanticipated. As will be seen in the project results, much of the available literature was split into two camps; supportive of the LEED program and critical of the LEED program. Therefore, some of the conclusions presented in the available literature is suspect, especially as the raw data has not been published. This project has attempted to address the assumptions made in the literature and play the part of an impartial observer interested in improving the system rather than defending or condemning it.

PROJECT RESULTS AND IMPLICATIONS

INTERPRETATION OF DATA

NORMATIVE SYSTEM:

Due to the design and construction requirements of the Energy Policy Act (EPAct) of 2005 and the Executive Order 13423 (Presidential Documents, 2007), all new buildings and major renovations, where the work exceeds 50% of the building's plant replacement value (PRV), must comply with EPAct 2005 (NAVFAC, 2007). This EPAct states all projects must be registered as certified by the U.S. Green Building Council (USGBC) as meeting the Leadership in Energy and Environmental Design (LEED) Silver rating. To earn a LEED Silver rating, a building project must earn a minimum number of points by following the LEED point system and by meeting all minimum design characteristics as required by LEED program. Prior to

being awarded any points, the construction site and building must be inspected by a LEED certified inspector at key points during construction and at commissioning (USGBC, 2012). For the current fiscal year of 2013 (October 2013 to September 2014), the military new construction budget is $9.6 billion (U.S. Department of Defense, 2012). Studies have found that building to the LEED Silver level to add a 2% premium to new construction (Kats, Alevantis, Berman, Mills, & Perlman, 2003) (Nyikos, Alfred Thal, Hicks, & Leach, 2012) (Stegall, 2004). Thus, the mandate adds $192 million to the annual construction costs. Despite the money being spent on the program, there has yet to be a comprehensive third party review of the holistic success of the program's stated goals.

As mentioned above, the LEED program addresses seven topics, the following chart explores the main points of each topic:

Topic Area	Main Points
Sustainable Sites	26 Possible Points, intended to protect undeveloped areas, lessen the impact of development, and reduce energy usage outside of the building through promoting alternative transportation.
Water Efficiency	10 Possible Points, intended to reduce water usage by at least 10% and promote wastewater reuse
Energy and Atmosphere	35 Possible Points, intended to reduce energy use by at least 10%, support alternative energy, and insure proper Refrigerant management
Materials and Resources	14 Possible Points, intended to promote recycling, manage construction waste, and use regional, renewable, and recycled materials
Indoor Environmental Quality	15 Possible Points, intended to promote a healthy indoor environment by increased ventilation, air monitoring, low-emitting materials, and increased daylight/views
Innovation in Design	6 Possible Points, LEED accredited professional on the job and innovation in design
Regional Priority	4 Possible Points, defined by region

Figure 2: Normative System (USGBC, 2012)

The LEED program includes more than building energy savings. Ideally, not only would the building be more energy efficient, but the building would be constructed in such a manner as to decrease the overall environmental footprint and fit into the large social system in such a way as to promote "green practices". An example of this is the emphasis on alternative transportation. There are studies which show the energy required by commuters driving to an office building is 2.4 times the amount of energy actually used by the building (Wilson, 2009). Conceivably, influencing building occupants to use transportation alternatives to personal, internal combustion engine vehicles, more overall energy could be saved than by addressing the operation of the building. In addition, the mandated construction methods, "green" energy requirements, and building materials were intended, in part, to create a market for these goods.

The ultimate goal of this market was to make the materials and practices mainstream enough to effect construction which was not affiliated with the LEED program.

CURRENT SYSTEM:

Viewpoints on the current system vary greatly between the supporters and critics of the LEED program. The disagreement seems to center on the realized ROI for the additional cost associated with the LEED program. The detractors focus on the energy savings, while the supporters attempt to take a more holistic approach. The report will build a picture of the current system using the concept of complementarity, in which different viewpoints of a system are both correct and incorrect depending on the observers' unique perspectives. By taking information from all viewpoints, the system can be better understood. In this case, the supporters of the LEED program take into account such intangibles as "building inhabitants' increased productivity" (Kats, Alevantis, Berman, Mills, & Perlman, 2003). Detractors focus mostly on the lack of energy savings for LEED buildings (Gifford, 2009) (Oates & Sullivan, 2012) (Scofield, 2009) (Siegel, 2011) (Stegall, 2004). The correct answer is probably somewhere in the middle of these arguments.

Of the reports supporting the LEED program, one of the most commonly cited studies by LEED proponents is a report to California's sustainable building task force, "The Costs and Financial Benefits of Green Buildings." This report found a $48-$67 Net Present Value (NPV) per square foot for LEED buildings over 20 years:

Figure XI-1. Summary of Findings (per ft^2)

Category	20-year NPV
Energy Value	$5.79
Emissions Value	$1.18
Water Value	$0.51
Waste Value (construction only) - 1 year	$0.03
Commissioning O&M Value	$8.47
Productivity and Health Value (Certified and Silver)	$36.89
Productivity and Health Value (Gold and Platinum)	$55.33
Less Green Cost Premium	($4.00)
Total 20-year NPV (Certified and Silver)	**$48.87**
Total 20-year NPV (Gold and Platinum)	**$67.31**

Source: Capital E Analysis

Figure 3: Financial Benefits (Kats, Alevantis, Berman, Mills, & Perlman, 2003)

This is an outstanding ROI. If this ROI was truly realized, these building methods would not require a Federal mandate. However, the ROI does not withstand scrutiny. The energy value is based on projected data, not actual data. In other words, this study took the commissioning simulations at face value without verifying the claimed energy savings. The emissions value was calculated off of the above energy use simulation. The water value is also based on projected data, but most of the water savings was from not using any potable water for landscaping. Thus, the water savings may be accurate, but represents a very small portion of the estimated ROI. The commissioning operations and maintenance (O&M) savings were found by assuming increased productivity in the labor required to operate the buildings because of the LEED standards. The largest portion of the ROI was generated by "productivity and health value" as seen above (Kats, Alevantis, Berman, Mills, & Perlman, 2003). The theory behind this value is LEED buildings make the inhabitants healthier and happier by having increased air flow,

better air filtration, more natural light, and materials which are less toxic. This increase in wellbeing was then assumed to result in less sick days, lower employee turnover, and overall improved employee effectiveness. Though there have been some studies which show a loose correlation between a building and employee productivity, other reports have found no scientific evidence of LEED buildings making occupants healthier or more productive. There are studies which "sick" buildings (building with improper airflow and excessive moisture) can make occupants less healthy, but modern building code has largely solved these issues (Kats, Alevantis, Berman, Mills, & Perlman, 2003) (Nyikos, Alfred Thal, Hicks, & Leach, 2012). Also, the NPV was found using a discount rate of only 5%. This is contentious because California uses a different rate of return at 7.5% for the state's primary investment vehicle; California Public Employees' Retirement System (CALPERS) (Marois, 2014). Also, the authors of the report used higher discount rates when it would result in a more favorable ROI (Nyikos, Alfred Thal, Hicks, & Leach, 2012). Therefore, none of the supposed ROI in this report were verified, and the portion of the report which dealt with energy saving is very misleading. Despite this, the report does do a good job at looking at the LEED program holistically, and generally shows the program is meeting expectations outside of energy savings.

A 2012 report, based on a literature review, found the operating cost benefits of LEED buildings to be a savings of $0.70 per square foot per year, at an initial average cost of $5 per square foot. Using the same parameters of the California study above, this study found a LEED Certified or Silver building has a NPV per square foot of $2.09 over a twenty year lifecycle. However, this study also did not use primary utilities data in most cases, and instead primarily relied on the commissioning energy simulation to determine energy savings. One important point made during this report was that an average cost of $5 per square foot is relatively low,

when compared to other options. For example, the cost of a building could easily be raised $5 per square foot by some of the more expensive flooring options which offer no monetary ROI (Nyikos, Alfred Thal, Hicks, & Leach, 2012).

The remaining literature on the subject is more critical of the LEED system and focuses on the lack of energy savings in the operation of the buildings (Siegel, 2011) (Stegall, 2004) (Oates & Sullivan, 2012) (Gifford, 2009) (Scofield, 2009). In part, buildings built under the LEEDS program are handicapped in regards to energy usage reductions due to restrictions on the LEED building and additional requirements imposed by the LEEDS program. Restrictions include materials and energy sources used. Additional requirements include such elements as increased outside views and increase outside air dispersion to commonly occupied areas. This was found to be the case in the building of the New Home Residence Hall at Carnegie Mellon University (CMU). Prior to building to LEED standards, CMU already stressed using sustainable building methods and reducing utilities usage over the lifecycle of the building. CMU had begun construction on the building prior to making the decision to seek LEED certification. Despite being out of the planning phase, CMU found relatively few changes had to be made to the building. In fact, LEED certification cost less than 2% of the overall cost for the building. The primary construction cost increase was from building a forced air system to bring fresh air to every regularly occupied room, rather than to just common spaces as per code. The primary operating cost increase was from the requirement to use electricity from "green energy" sources, in this case wind, and to support the more aggressive ventilation system. Prior to these changes, the building was designed to use primarily steam for heating, which was cheaper than electrical heating but powered by natural gas. Though these changes may have contributed to the (unverified) better health of the students, it increased the utility costs by $8,410 to $12,744 or 6%

to 12% per year (Stegall, 2004). To get the two points for green power, at least 35% of the buildings energy use had to come from a two year renewable energy contract. This disallowed the use of steam to heat the building. "Green energy" sources are restricted to solar, wind, geothermal, some biomass, and some low-impact hydro sources, which disallows traditional hydro sources, bio-gas, and nuclear (USGBC, 2012). Furthermore, these requirements are contradictory as they are more restrictive than acceptable renewable energy source for onsite generation found elsewhere in the LEED standards (USGBC, 2012).

A study of post-occupancy energy consumption in Arizona found only one building which performed better than the commissioning simulation, four that outperformed conventional buildings but did not match the commissioning simulation, and the remaining thirteen performed worse than buildings built in the same region and timeframe (Oates & Sullivan, 2012). Two additional studies which looked at the data presented by the USGBC to show a reduction in energy usage, found fault with the data analysis. One of the largest discrepancies was the treatment of statistics. The USGBC report compared the statistical median of LEED buildings energy usage to the mean of non-LEED buildings energy usage. In addition, the USGBC study compared LEED buildings to all other non-LEED buildings still in use. This included buildings built over a hundred years ago and for widely varying usages. Once the mean of LEED buildings' energy usage was compared to the mean of buildings of the same use and vintage; the LEED buildings used more energy than the conventional buildings. This study also points out only half of the building operators track energy usage data after commissioning (Gifford, 2009). Of those LEED buildings which reported data, LEED Certified buildings used more energy, Silver the same amount of energy, and Gold/Platinum 13% less energy than comparable conventional buildings (Scofield, 2009). Still more critics found more than half of LEED

certified buildings would not qualify for the EPA's Energy star rating, and one quarter of LEED buildings demonstrated energy performance below the national average. The likely cause of this is the energy savings are based on computer models developed for the commissioning of the building. Though there are extra points awarded for a plan to track utility usage for five years following commissioning, but there is no requirement by the USGBC to follow the plan once certified and no penalties if the building under performs (Siegel, 2011). Thus there is no incentive to realize the claimed energy savings.

Another major concern of critics of the LEED program was the lack of allowances for regional issues. In response, the LEED Regional Bonus system was implemented in April 2009 to address criticism of earlier versions that used a one-size-fits-all metric for buildings in very different settings. In general this program consist of the following:

> These regional priority credits provide incentive to address geographically specific environmental issues, USGBC regional councils and chapters have identified 6 credits per rating system that are of particular importance to specific areas. Each regional priority credit is worth an additional 1 point, and a total of 4 regional priority points may be earned. Upon project registration, LEED-Online automatically determines a project's regional priority credits based on its zip code. If the project achieves more than 4 regional priority credits, the team can choose the credits for which these points will apply (USGBC, 2012).

At 4 possible points out of a required 50 for LEED Silver certification, the program is still mostly an "one-size-fits-all" rating system (Overbey, 2013). Furthermore, the regional point system specifics are only available to LEED Accredited Professionals, making the program details unavailable for this report.

Overall, the current LEED system meets all the goals set by the USGBC except for energy savings. This is largely due to the energy savings being the only goal for which the program is on the wrong side of both positive and negative feedback. There is no accountability for missing the energy goals as the lack of energy saving is only apparent after the building has been put into commission and has already been awarded the LEED certification; providing no negative feedback. Energy savings is the most expensive avenue of gaining LEED certification, which gives the company constructing the building positive feedback for skimping on energy saving methods. Thus it is not surprising the system fails to produce energy savings.

CONTEXT:

To put the LEED system in context, the program was created by USGBC; a committee which included architects, realtors, building owners, lawyers, environmentalist, and construction industry representatives. Their goal was to set a national standard for green buildings. They then lobbied the federal government to implement the standards, which was done by President Bush in 2007 with Executive Order 13423 and codified into law by the 2009 Omnibus Appropriations Act as discussed above. This has caused some critics to suspect the standards are purposely not difficult to meet and, due to the way the requirements are written, requires products from specific companies (Gifford, 2009) (Scofield, 2009). The largest controversy has been over certified wood products, in which the LEED program only recognizes one wood certifying agency. This has become so contentious, four states (Maine, Georgia, Alabama, and Mississippi) have banned LEED certification until other wood certifying agencies are recognized (Law, 2013). One of the strengths and weakness in the LEED system was the standardization of requirements to build a "green" building. This is a weakness because it does not allow much flexibility in designing for regional issues. However, it does ease the design process for construction/design companies

which operate on a national level. Prior to the LEED system implementation, different areas and institutions had developed local requirements for "green" buildings (Stegall, 2004) (Oates & Sullivan, 2012). The LEED system provides a baseline expectation between the contract solicitor and contractors when discussing "green" building practices.

USGBC has admitted the LEED system is not particularly difficult to implement, but the USGBC maintains the LEED system walks a fine line. If the requirements are too lax, there will be no significant changes to construction of new buildings. However, if the requirements are too stringent, the LEED system will not be used. This will hamper the growth of the system, and reducing the "greening" of new construction in holistic terms. While this is undoubtable true, administrative costs are nearly 50% of the price of gaining LEED certification (Stegall, 2004). Especially when the system fails to meet the claims made by the USGBC, the USGBC looks like the primary beneficiary of the system.

PROBLEM SYSTEM ANALYSIS:

After completing the literature review above, the key difference between the normative system and current system is the LEED system prioritizes other goals over energy conservation. For example, the most heavily incentivized goal is the location of new construction. When analyzing the CMU cost/benefit analysis on building to LEED standards, CMU had to change very little in their construction plan. The increased cost of LEED Silver certification was less than two percent, approximately half of which was administrative in nature. Actual changes to construction added only about one percent in costs. The reason for this was the location of the new building. By being located in an urban area, (in this case Pittsburgh, Pennsylvania) CMU was awarded fourteen points of the fifty required for LEED Silver. As this was determined by comparing CMU's plan to the USGBC point guild, there are actually more points available to

influence the location of the LEED building than is shown below. These were the points claimed by CMU:

Category	Points	Explanation
Site Selection	1	The location was not: Farmland, Flood Zone, Wetland, or Parkland
Public Transportation Access	6	Within ¼ mile of bus route
Bicycle Storage and Changing Room	1	As it is within a city, this was already part of the design
Parking Capacity	2	No additional parking was required to be built because of existing parking
Green Power	2	Green power was available for purchase
Local/Regional Materials	2	Pittsburgh is situated in an industrial region making this easy to obtain.
Total	14	

Figure 4: Location Points (USGBC, 2012) (Stegall, 2004)

Although fourteen credits may seem insignificant, a further analysis of the LEED program demonstrates otherwise. Other than the occupant welfare concerns and administrative burden, the LEED program is not considerably more arduous than present building code and construction industry best practices (Stegall, 2004). The following chart is a collection of the most easily gained points. These points do not overlap with the above table of points earned by CMU for locating the new dormitories in an urban environment. As can be seen, relatively minor changes are needed in order to gain 40 points for a renovation and 36 for new construction:

Category	Points	Explanation
Protect or Restore Habitat	1	This limits the effect of construction to the immediate area. Already best practice.
Development Density and Community Connectivity	5	Build in a densely populated area on a site which has been

		previously developed.
Heat Island Effect – Non-roof	1	Provide shade for 50% of hardscape or use materials with an SRI of at least 29
Water Efficient Landscaping	4	Reduce by 50% potable water usage on landscape
Enhanced Commissioning	2	Start the process for already required commissioning early and use an independent, experienced, commissioning authority
Enhanced Refrigerant Management	2	Already required by the EPA.
Measurement and Verification	3	Have a PLAN to verify the building is operating as found in the Commissioning Model for up to 5 years
Building Reuse	1-3	Reuse the walls, floors, and roof of a building to be rehabilitated.
Building Reuse-Nonstructural	1	Reuse 50% of a rehabilitated building's Nonstructural components
Construction Waste Management	1-2	Recycle (sell) or donate waste up to 75% for full points
Recycled Content	1-2	Most metal manufacturing process include some recycled material. Similarly, ceiling tiles and drywall commonly contain recycled materials, and most carpet manufactures use recycled carpet fibers to some degree.
Rapidly Renewable Materials	1	2.5% from plants harvested within 10-years cycle
Certified Wood	1	Use 50% by cost wood certified as sustainable by the Forest Stewardship Council. Many of the standard wood products meet this requirement.
Outdoor Air Delivery Monitoring	1	Install a monitoring system to ensure CO2 levels meet the design value
Construction Indoor Air	1	Ensure there is no moisture

Quality Management Plan During Construction		damage to materials and add extra filters to the ventilation system to keep it clean during construction
Construction Indoor Air Quality Management Plan Before Occupancy	1	Flush the ventilation system with outside air for two weeks
Low-Emitting Materials-Paints and Coatings	1	Use paints and coatings with low VOC content
Low-Emitting Materials – Flooring System	1	Most standard flooring systems meet these requirements.
Low-Emitting Materials – Composite Wood and Agrifiber Products	1	Cannot contain urea-formaldehyde. Many such materials exist and are not difficult nor expensive to source
Indoor Chemical and Pollutant Source Control	1	Permanent entry way grates or mats to prevent dirt, rooms with high chemical us are exhausted out of the building and have a drain. Most modern buildings are already thus designed
Controllability of Systems – Lighting	1	Allow 90% occupancies of a building to control the lighting.
Controllability of Systems-Thermal Comfort	1	Allow 50% of occupants to control the temperature of the room. Windows count.
Thermal Comfort- Design	1	Temperature 70-78 degrees F, Humidity 30-60%
Thermal Comfort-Verification	1	Install a system to monitor temperature and humidity
LEED Accredited Professional	1	At least one principle member of the project team is a LEED Accredited Professional – $299.00 for 10 hours of online instruction, and $200 for an exam
Total	36-40	

Figure 5: Easily Obtained LEED Points (USGBC, 2012)

Thus, up to 40 points can be obtained before addressing more than the minimum energy and water conservation requirements. This is enough to be LEED Certified. By adding the

additional 14 points gained by building in a major metropolitan area, LEED Silver (50 points) is also easily gained without major cost or changes to modern building design. In fact, CMU made the building LESS energy efficient than previously designed in order to get the green energy credit because the ease of meeting the other requirements did not require CMU to make the building more efficient. In fact, the maximum points available for reducing energy usage is only 19 points, but requires a 48% energy savings over the baseline. To equal the points gained from locating the building in a metropolitan area through energy reduction, the energy usage would have to be reduced by 38%. Though there are other ways of earning the additional points to obtain LEED Silver if not located in a city; none are as cheap or easy as the points listed above. From this standpoint, it appears the LEED program incentives location of construction over actual significant energy and water usage reduction in building operation. The same analysis can be made for the other goals of the LEED program, which identifies energy savings as the most disincentivized goal.

DISCUSSION OF PROJECT DELIVERABLES

The report moved the situation forward by identifying the mechanisms by which the energy savings are not being realized. As was shown above, plenty of literature identifies the lack of energy savings in LEED buildings and the dishonesty associated with selling the LEED program as an energy reduction program. However, none of these journals, articles, and reports attempted to identify the systemic causes of this shortcoming. By identifying the mechanisms, changes to the system can be recommended. Thus, I find the course project has been successful. Furthermore, I plan on taking the information gleaned from the report to hold contractors and the LEED system accountable for the new construction under my oversight in the future.

RECOMMENDATIONS/PROJECT RESULTS

TARGET SYSTEM SYNTHESIS:

In order to make the energy savings match the advertisement for the LEED program, several changes could be made to the system. The bar to become LEED certified could be raised, and accountability for the energy savings simulation could be implemented. Energy savings is not the only goal of the LEED system, so the points which are easily obtained should not be removed. The points were included because they were found to be important to the system stakeholders. However, if all the levels of LEED certification were raised by five to ten points, additional energy saving measures would become more likely to be included.

As shown above, the minimum required energy savings is 10% savings over a baseline building performance as rated in Appendix G of ANSI/ASHRAE/IESNA Standard 90.1-200. However, the only proof required for this is a computer simulation model (USGBC, 2012). When these computer simulations were compared to actual performance, only 5% of buildings performed as well as the computer simulation promised (Oates & Sullivan, 2012). This resulted in no penalties or action on the part of USGBC, and all buildings continued to retain the awarded LEED certification. As energy usage reduction is one of the most expensive points to earn under the LEED system, there exist a strong positive feedback to not take the steps to save energy if the computer simulation can be shown to save energy instead. To solve this problem, there needs to be accountability for the computer simulation. One option could be awarding a provisional LEED Certification/Silver/Gold/Platinum at commissioning. The actual building performance would then be tracked over a five year period. This would not be difficult to implement as the LEED program already requires, but does not enforce, a five year metrics tracking plan

following building commissioning. If performance metrics are not met, the certification could be suspended or revoked based on issue resolution.

TRANSFORMATION STRATEGY:

The likelihood of these changes of being implemented are low. As was shown earlier, the majority of stakeholders seem to be pleased with the current system. The two stakeholders with motivation to change the current system are manufactures of energy usage reduction solutions and those paying for the energy used by the buildings. These manufactures could conceivably lobby lawmakers to make the changes recommend above. However, most of these manufactures also sell the less efficient energy systems and may not see a good return on investment on lobbying for more actual energy savings.

Currently, most of the buildings are being utilized by the government and the energy costs are not being rigorously tracked. However, if an owner of a LEED certified building were to sue the USGBC, it would be possible to affect change in the system. In fact, there was a class action lawsuit against the USGBC for lack of realized energy savings filed in 2011 (Cheatham, 2011). The case was subsequently dismissed due to the plaintiffs' inability to establish standing. They claimed, as design and construction professionals specializing in energy savings, they had lost business due to the LEED program falsely advertising energy savings at a lower cost. The judge disagreed (Shapiro, 2011). Obviously, the best plaintiff would be the Federal Government. Due to the energy monitoring system required by the LEED program, energy usage should be easy to track. However, this is unlikely to happen because it would significantly raise the difficulty and cost of LEED Silver certification. Also, the Federal Government would be partially responsible as they oversee the construction and verify the plans and models for LEED certified federal buildings.

Finally, the system could be changed by the USGBC unilaterally in order to maintain their status as the premier green building certification organization. Though it would make the certification process more difficult and may slow the growth of the LEED program in the short term, it would improve long term viability. At the current time, the LEED program is not delivering the results as promised. While this "green washing" may make stakeholders looking for a largely political solution happy for a while, eventually building owners/taxpayers will want to receive the product for which they pay a premium.

The LEED system is an interesting problem in that it has laudable goals and does result in more pleasant buildings. The main criticisms are based on an interpretation of a "green" building to mean less energy usage. However, the mission statement of the LEED program is "to promote healthful, durable, affordable, and environmentally sound practices in building design and construction (USGBC, 2012)." Of the seven areas by which points can be gained, only one area actually treats energy conservation and is the only goal which is not being met. Overall the LEED system has had some success. The program has made recycled/renewable/safer buildings materials more mainstream. The buildings make alternative transportation to and from the buildings easier. The buildings support alternative energy generation. The buildings are more likely to be built in dense urban areas and leave undeveloped land pristine. The buildings are arguably more pleasant and healthier for the occupants. For example, the addition of forced fresh air and having 90% of all regularly occupied spaces having a direct view of exterior windows at CMU may in fact be worth the extra construction and utility costs. However, the most highly touted benefit of the program is energy savings, which has not been realized.

LOCAL LEVEL IMPLICATIONS/RECOMMENDATIONS:

The local level implications and recommendations generated by this report are both the Navy and the City of Norfolk should start tracking the energy usage for all buildings. This data can then be used to compare the energy usage to non-LEED buildings of the same vintage and usage along with the commissioning simulation. This should not be difficult as the resources to track the energy usage was required to be built into the buildings by the LEED program. While retroactive changes to the buildings are unlikely to happen, if the energy usage is significantly higher than was promised, this information should be used to ensure new buildings do not suffer the same fate.

LOCAL LEVEL ISSUES IDENTIFIED AS A RESULT OF THE PROJECT:

The shortage of energy usage data and unavailability of the simulations used to get the LEED credit are astounding. Given the cost of implementing the program and the ongoing cost of utilities, the results should be tracked. Just the act of tracking the data could identify areas which are not operating correctly. Using even the most basic quality design engineering practices would ensure there were not emergent conditions increasing the energy usage even further.

PROJECT IMPLICATIONS BEYOND THE LOCAL LEVEL:

As seen above, the LEED program is implemented worldwide. The primary justification for this is energy savings. If these savings are not being realized, the system needs to be changed to bring the system products in line with the system goals.

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STUDENT BIOGRAPHICAL DATA

I was born in Portland, OR, and lived near Hillsboro, OR until I was eight. I then lived in Gustine, California for seven years, and finally went to high school in Murray, Utah; graduating in 1999. My father worked in agriculture until he went back to school in his forties to earn a PHD in business. He now teaches at University of Idaho. My mother was a school teacher and then a network administrator. She now is the director of the distance learning program at the University of Idaho. I have two brothers, both of whom graduated from the United States Naval Academy (USNA) and are now US Marine Corps pilots.

I attended the USNA, graduating with a BS in Naval Architecture in 2003. I was commissioned as a Surface Warfare Officer (SWO), and had my first duty assignment on the USS (LHD 2) Essex in Sasebo, Japan. I was stationed in Japan for two and a half years, and spent most of my time deployed to South-East Asia and the Arabian Gulf. I served as the Combat Information Center Officer for the first half of my tour and as the Auxiliaries Officer for the second half. A highlight of this tour was doing disaster relief after the tsunami in Indonesia. In the fall of 2005, I was transferred to USS (FFG 40) Halyburton, homeport in Jacksonville, FL, as the training officer. Most of my time on this ship was spent deployed to western South and Central America. In 2007, I married Rebeccah Rodrigues and transferred to Naples, Italy as part of the Sixth Fleet Staff. I was part of the Africa Regional Group and was heavily involved in Africa Partnership Station. In 2009 my application for lateral transfer out of SWO and into the Civil Engineer Corps (CEC) was accepted, and in 2010 I attended the CEC Officer School. In February, 2010, my daughter, Mollie was born. Shortly thereafter, I was assigned to Naval Mobile Construction Battalion (NMCB) 133 in Gulfport, MS. I joined the battalion on deployment to Kandahar Airfield, Afghanistan. During the next two years, I served

as the transportation officer (A6), with one short opportunity to lead a small detachment to Ha Tihn, Vietnam for humanitarian work. Along with Afghanistan, I was also deployed to Okinawa, Japan for ten months. Three months after returning from Okinawa, I was deployed to Djibouti, Africa for a year as a construction manager. In February, 2014, my son, Liam was born. I am now pursuing a ME in Engineering Management as part of the CEC graduate school program. I am on schedule to graduate in May 2014. For entertainment, I enjoy reading, working on the house or cars, weightlifting, playing Rugby, and spending time with my family. We also have three dogs.